U.S. Department of Energy
Energy Efficiency and Renewable Energy

Mechanical Systems - Enhancing Technologies

# High Performance Heating Systems

Rebuild America
U.S. Dept. of Energy

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## Question:

- Who likes to save money?
- Who believes “simple” is better?
- Who doesn’t like to save money?
- Who believes “complicated” is better?

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## Chelmsford High School - 33% Saving a Year!

After 25 years the existing cast iron boilers were replaced with a 10 million BTU/hr. high efficiency boiler plant. The boiler plant has a total input in five (5) independent units.

After a complete year of operation, the system reduced fuel consumption 33% based on the owners figures.

## Marblehead High School - 30% Saving a Year

This high school was designed around a 40°F temperature differential to take advantage of the condensing operation of high efficiency boilers.

Burning only and exactly the fuel needed, the high efficiency boiler plant is projected to save 30% or more of the energy used with a conventional heating boiler plant.

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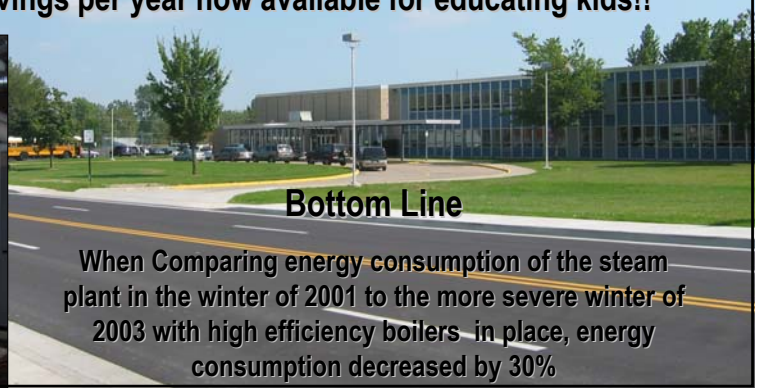
# Geyer Middle School, IN

**Geyer Simplifies their heating system by eliminating two (2) 42 year old large steam boilers and converted the system to hot water and installed high efficiency hot water boilers**

**30% Savings per year now available for educating kids!!**



## Bottom Line

**When Comparing energy consumption of the steam plant in the winter of 2001 to the more severe winter of 2003 with high efficiency boilers in place, energy consumption decreased by 30%**

# Cuyahago County BMR in Ohio

The Old Flex tube boiler either fired at 100% or it was off.

**High efficiency modulating & condensing boilers** have a inverse efficiency curve which means the lower the firing rate the more efficient the boiler.

**28% Savings**
**By Just Replacing a Conventional Flex Tube Boiler**

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# Efficiency Definitions

**Combustion Efficiency** – 100% minus the percent of energy losses at the exhaust (heat, CO2, free air and water vapor lost up the flue) - Flue Loss Method

**Thermal Efficiency** – Ratio of energy transferred to water compared to the total energy (gas & electric) consumed

**Seasonal Efficiency** - Overall Effectiveness of the Boiler Over the Entire Heating Season. Takes into account boiler operation at partial heating loads.

# Question:

- **Which one of these efficiency terms could best be used to compare real operating costs for any given Boiler at the gas meter?**
  - ***Combustion (Flue Loss)***
  - ***Thermal***
  - ***Seasonal***

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# What is Considered a High Efficiency Boiler?

**Conventional Efficiency: 80 - 83%**

**Mid Efficiency: 84 - 88%**

**High Efficiency: 89% and up (condensing)**

**Condensing**
**Captures *"latent heat"* for +90 + % efficiency by installing product with incoming water temperatures significantly below 140°F (warranty coverage)**

# What Defines Condensing Boilers?

**Condensing**

The 'regain' of energy that occurs when water vapor found in flue gas changes state (condenses), becoming a liquid.

**1 pound of condensate = 970 BTUs**

When condensing occurs within the heat exchanger, the additional energy (heat) is transferred to the boiler water.

**Why Condensing Occurs**

When flue gas drops below its dewpoint ~ 135°F condensing occurs.
Cool water surrounding the heat exchanger "cools" flue gases within.

**In general, you cannot achieve thermal efficiencies in excess of 87% without some condensing occurring.**

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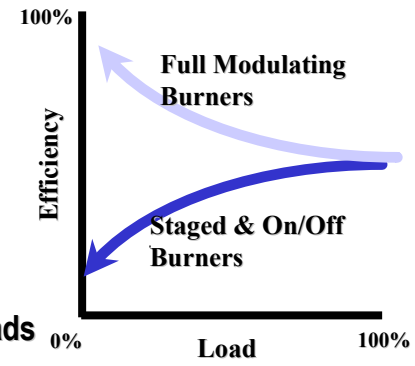
# Why Modulate the Fuel/Air Input?

- **Turndown Increases Efficiency**
  **Eliminates *Cycling* Losses**
  ***No Energy Waste***
- **Match Energy Input**
  **to Actual Heating Load**
  ***No Energy Waste***
- **Precise Temp Control at All Loads**
  ***Maximize System Efficiency***
  ***& Simplify Building Controls***



# Thermal Efficiency Rating

**BTU/hr = 500 x Delta T x GPM**

**Thermal Efficiency Measurement: (Energy out/Energy in) x 100**

**But…**

**Test Conditions Require: 80°F inlet water temperature**
**180°F outlet water temperature**
**100% Firing Rate (full capacity)**
**30-minute test period after "full soak"**

***This is NOT representative of typical heating applications!***

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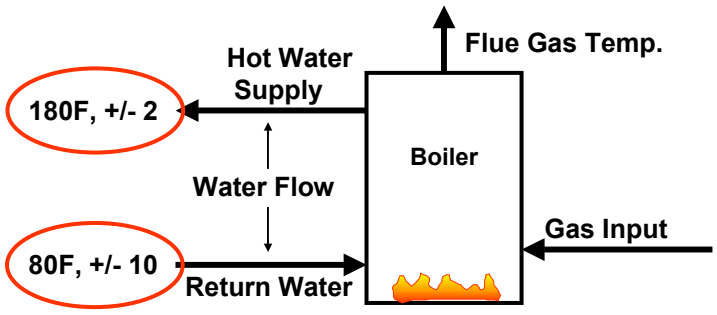
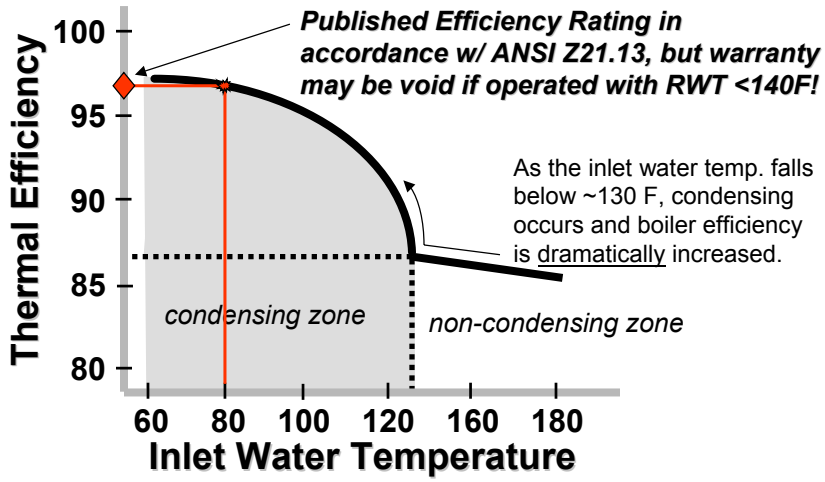
# ANSI Z21.13-2000: Thermal Efficiency Test

**300,000 Btu/h to 12,500,000 Btu/h**
**Test Boiler at Full Capacity**

***Thermal Efficiency = (Energy Out / Energy In) x 100***



# Inlet Water Temp Effect on Boiler Efficiency

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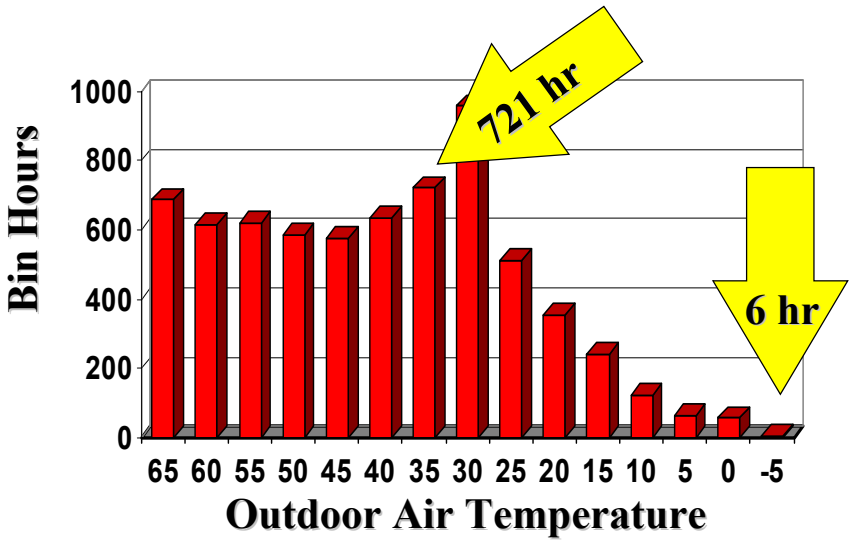
# ASHRAE Bin Data



## Assume Full Plant Capacity on Coldest Day

2000 MBH load at -5° F

2000MBH x 6 hrs. = 12,000,000 BTUs

That's 120 therms @ $0.50/therm = ***$60***

## Assume Partial Loads on Other Days

800 MBH load at 30° F

800MBH x 721 hrs. = 576,800,000 BTUs

That's 5768 therms @ $0.50/therm = ***$2884***

**When should the boiler operate most efficiently?**

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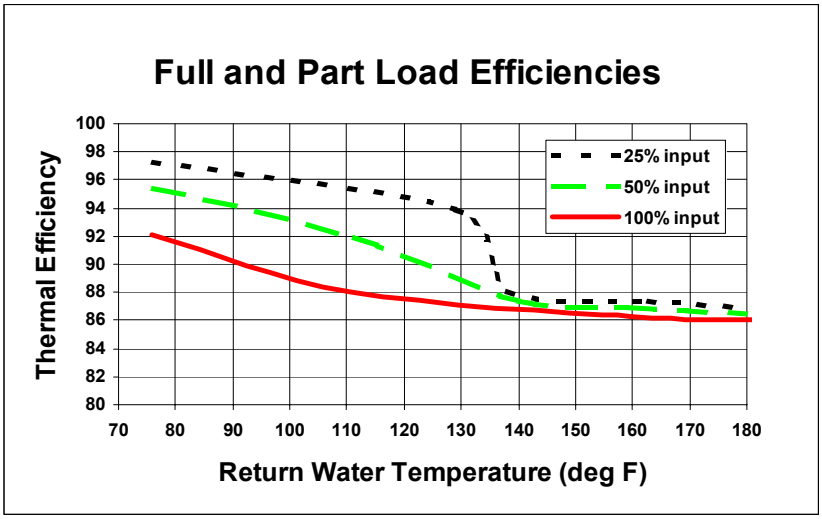

# How The Industry Modulates Its Firing Rate

## Examples:

Linkages from a Motorized gas Valve to a Damper on the Exhaust

or

Single Shafted Motorized Air/Fuel Valve

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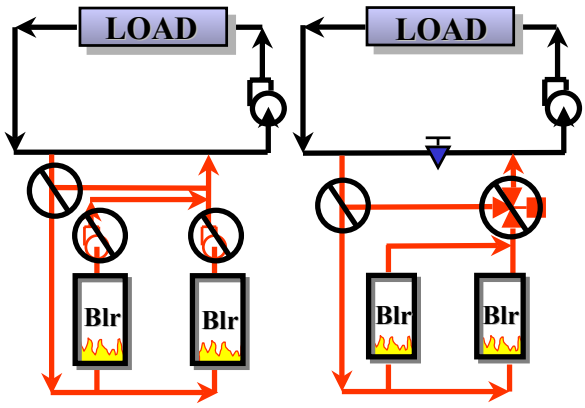
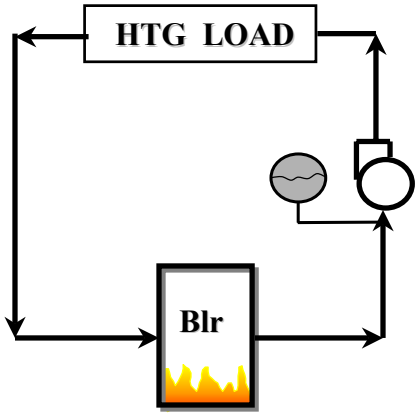
# Conventional Boiler Piping

### Primary/Secondary Pumping or Control Valve




Protect boiler:
- condensing
- thermal shock
- reduce standby losses

# High Performance Heating System




**Eliminates Auxiliary Components:**

- **Primary/Secondary Pumping & Controls**
- **2, 3 or 4 - Way Valves**

and

**Maximize System Efficiency**

**Maximize Boiler Efficiency**

**Reduced Installation Cost**

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# Maximizing Heating System Efficiencies

- **Increase Temperature Differential from 20°F to 40°F (or more)**

  **Result:** Smaller pipe size

  Lower pump horse power (cost and consumption)

  Improved /operation of valves & terminal units means better control over room temperatures

  Lower return water temps to condensing boiler means higher boiler efficiency

- **Variable Speed Pumps**

  **Result:** Energy Efficient, Better room temperature control

# How Can I Achieve 90%+ Average Seasonal Efficiency?

- Boiler must condense water vapor in flue gas under operating conditions
- Must reduce cycling losses by modulating boiler input at partial load conditions
- Must design the system to take advantage of boiler and controls technology

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# More Questions for the Industry?

- Does the boiler modulate? How much? How?
- Is the boiler a condensing boiler?
- What is the boiler constructed of?
- How diverse is the boiler's venting capabilities?
- Can I take advantage of the boiler capabilities in my overall heating system?

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# Thank You For Attending This


# Program